Exercises for EFT 1, Sheet 3

$$X = ax^2 + bx + c \qquad \Delta = 4ac - b^2 \qquad k = \frac{4a}{\Delta}$$

$$\int \sqrt{X}\,\mathrm{d}x = \frac{(2ax+b)\sqrt{X}}{4a} + \frac{1}{2k}\int \frac{\mathrm{d}x}{\sqrt{X}}$$

$$\int \frac{\mathrm{d}x}{\sqrt{X}} = -\frac{1}{\sqrt{-a}} \arcsin \frac{2ax+b}{\sqrt{-\Delta}} \quad \text{with} \quad a < 0\,,\, \Delta < 0$$

$$X = a^2 \pm x^2$$

$$\int \frac{x\,\mathrm{d}x}{X} = \pm\frac{1}{2}\ln X$$

Exercise 1. Determine the volume of a sphere with radius R_0 in cartesian coordinates and components and in spherical coordinates and components.

Exercise 2. An electron is moving in a homogeneous magnetic field with the magnetic flux density $\underline{\mathbf{B}} = 0,1\ \mathrm{T}\ \underline{\mathbf{e}}_z$. It has the start velocity

1.
$$\underline{\mathbf{v}}_0 = 3\frac{\mathrm{km}}{\mathrm{s}}\underline{\mathbf{e}}_z\,.$$

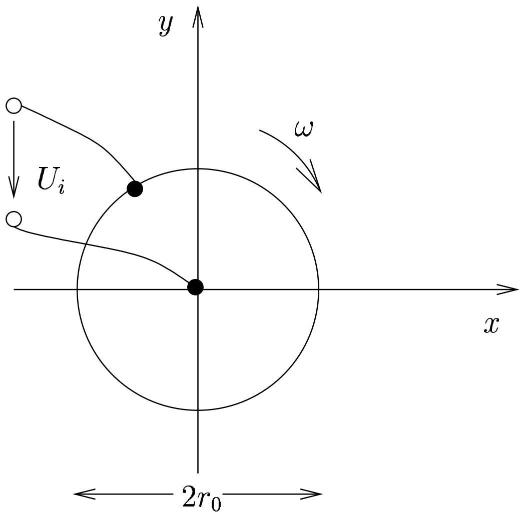
2.
$$\underline{\mathbf{v}}_0 = 3\frac{\mathrm{km}}{\mathrm{s}}\underline{\mathbf{e}}_y\,.$$

3.
$$\underline{\mathbf{v}}_0 = 3\frac{\mathrm{km}}{\mathrm{s}}\underline{\mathbf{e}}_x + 2\frac{\mathrm{km}}{\mathrm{s}}\underline{\mathbf{e}}_y + 1\frac{\mathrm{km}}{\mathrm{s}}\underline{\mathbf{e}}_z\,.$$

Calculate the magnitude of the force $\underline{\mathbf{F}}$ on the electron. Determine the path of the electron.

$$m_e = 9,11 \cdot 10^{-31}\,\mathrm{kg}, \quad Q_e = -1,602 \cdot 10^{-19}\mathrm{As}$$

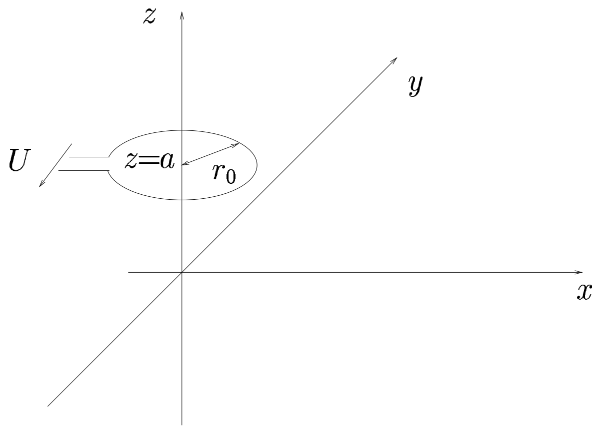
Exercise 3. A circular metallic plate (radius $R_0 = 50\mathrm{cm}$) is rotating with an angular frequency of $\omega = 300\ \mathrm{s}^{-1}$ in an inhomogenous magnetic field with the magnetic flux density $\underline{\mathbf{B}}(r) = B_0\frac{r}{r_0}\underline{\mathbf{e}}_z$ with $B_0 = 1$ T. The magnetic field is perpendicular to the metallic plate.



Calculate the induced voltage U_i between the axis and the border of the metallic plate.

Exercise 4.
A conductor loop with radius r_0 is located in the plane $z = a$ as shown in the figure.
The loop is located in a magnetic field with the magnetic field strength

$$\vec{H}(x,y,z,t) = H_0 r_0 \left(\frac{y}{x^2+y^2}\underline{\mathbf{e}}_x - \frac{x}{x^2+y^2}\underline{\mathbf{e}}_y + \frac{a}{x^2-az+y^2}\underline{\mathbf{e}}_z \right) \cos(\omega t + \varphi_0) \quad .$$



1. Determine the cylindrical components of the magnetic field density in dependence of cylindrical coordinates.

2. Calculate the magnetic flux Φ in the conductor loop.

3. Compute the voltage U induced in the loop.